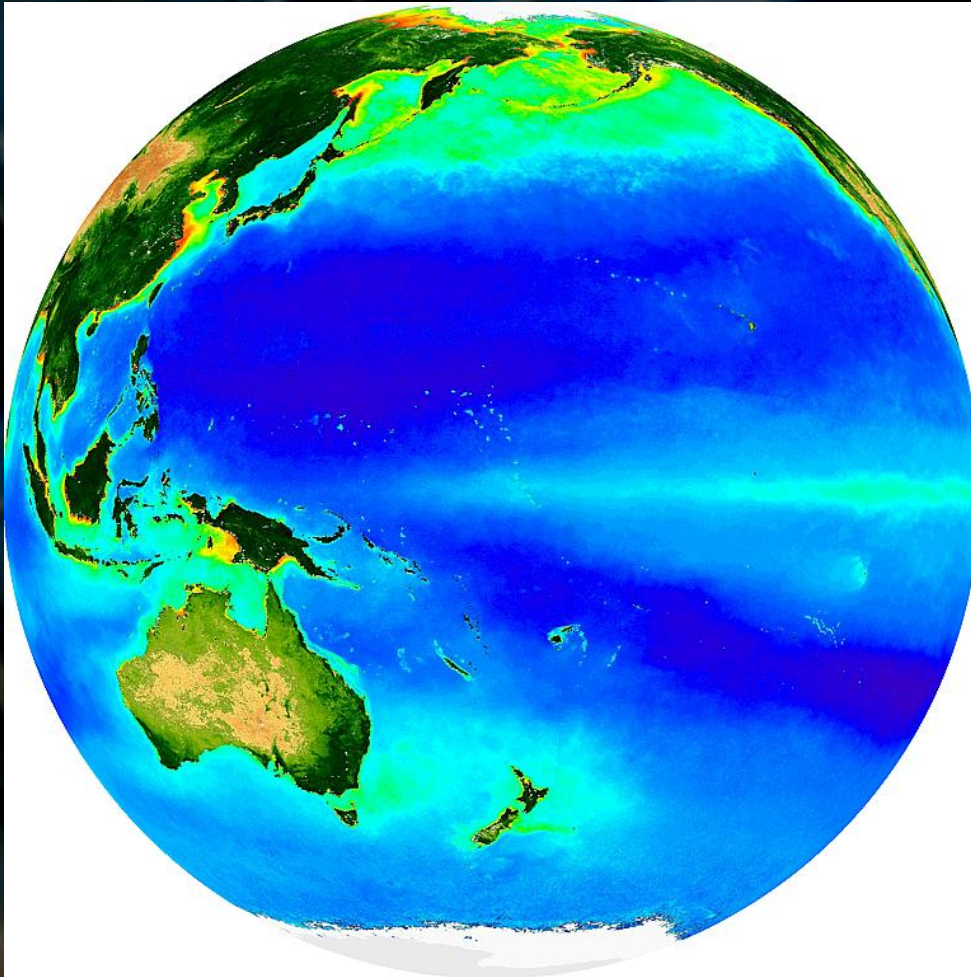
A composite image showing various microscopic marine organisms, likely from a satellite or deep-sea camera. The organisms are mostly blue and green, with some showing internal structures like eyes or antennae. They are scattered across the frame, with some appearing larger and more detailed than others. The background is dark, making the organisms stand out.

Ocean ecosystems from space: Moving beyond chlorophyll:

Anand Gnanadesikan
NOAA/Geophysical Fluid Dynamics Lab
November 16, 2010

SeaWiFS chlorophyll



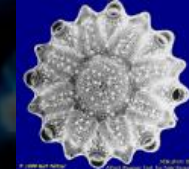
- Contrast between ecosystems (clear gyres/turbid margins).
- Changes in event timing

What we want to know

- How are ecosystems changing both as a result of climate variability and climate change?
- How much carbon is the ocean storing?
- How is the absorption of radiation within the ocean changing?

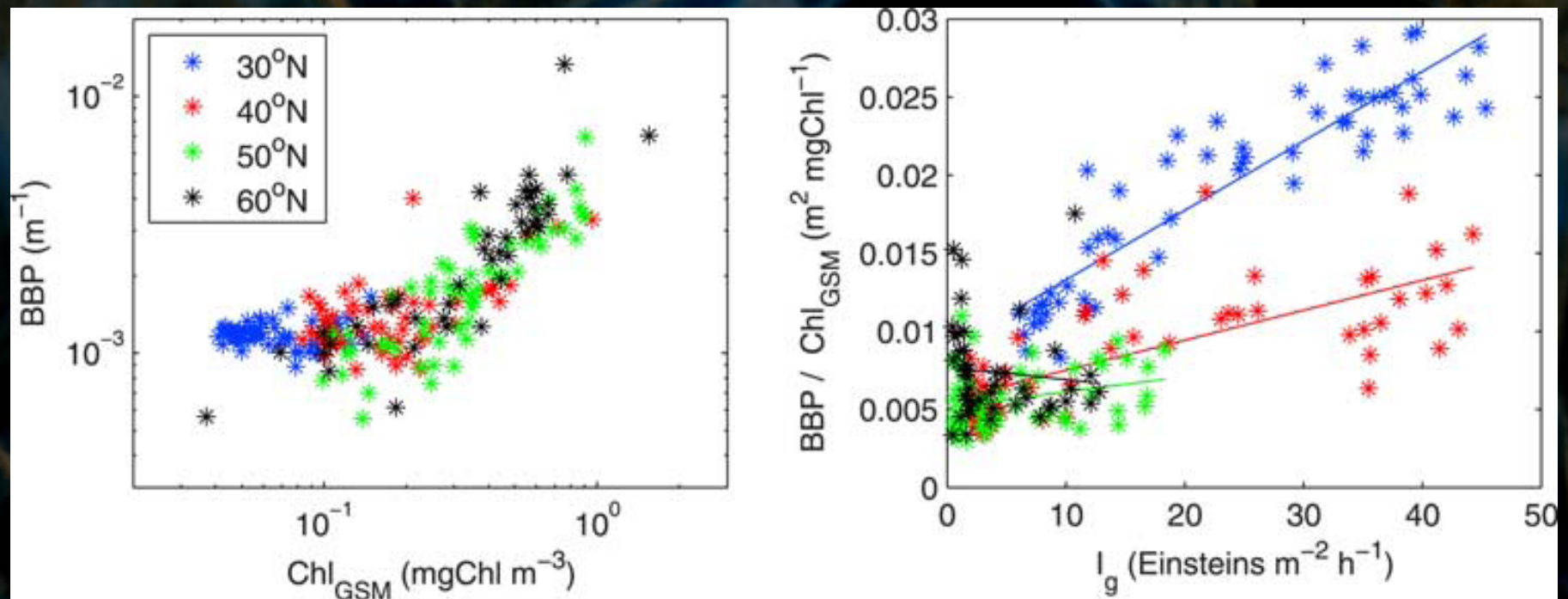
Why chlorophyll is a tricky indicator by itself

- Chl \neq Biomass
 - Photoadaptation
 - Chl:C and iron
- Chl \neq Fish food
- Chl \neq Carbon sequestration
- Chl \neq Absorption



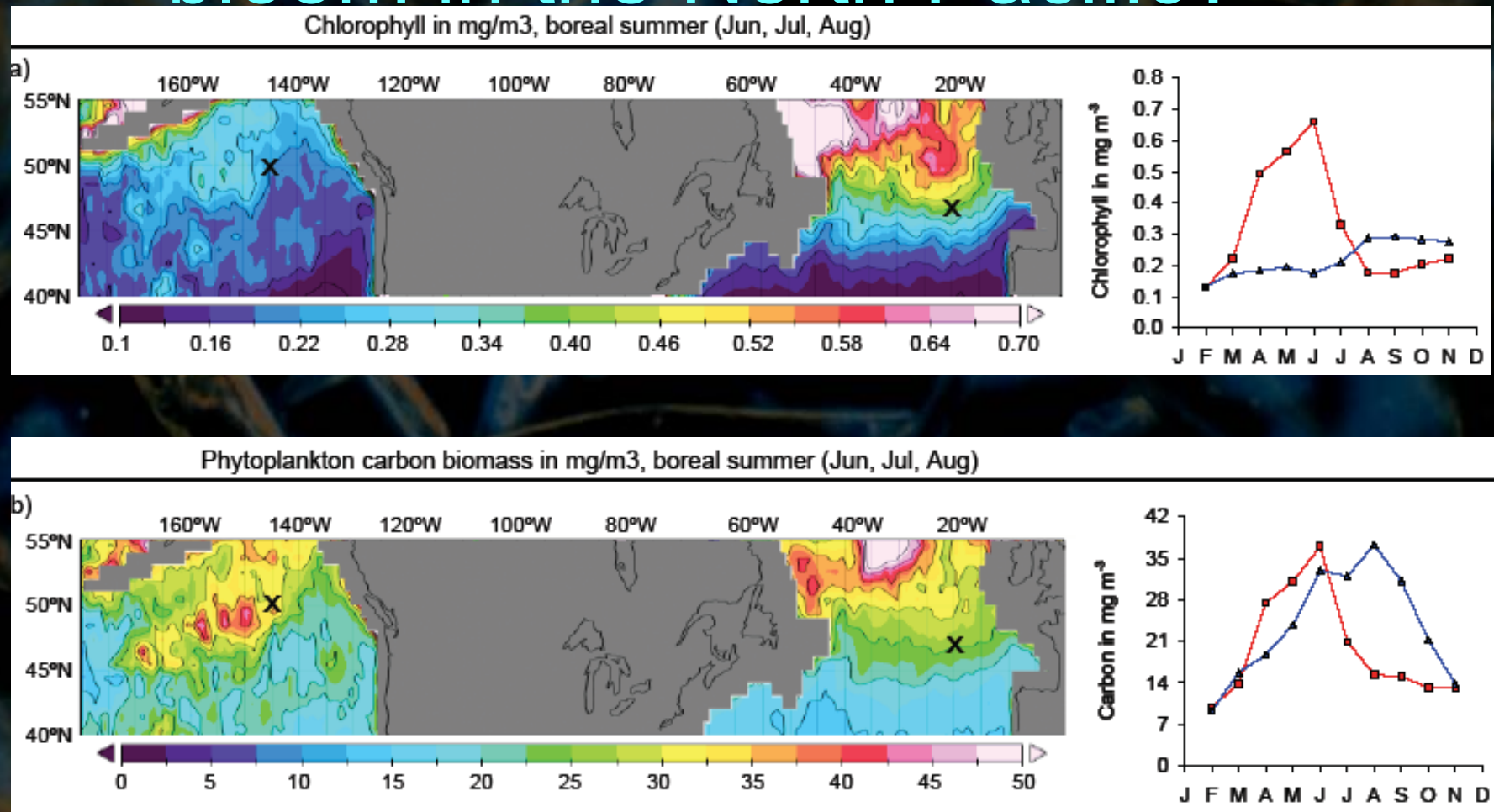
But there are good ideas for extending chl to other products

1. Backscatter and biomass



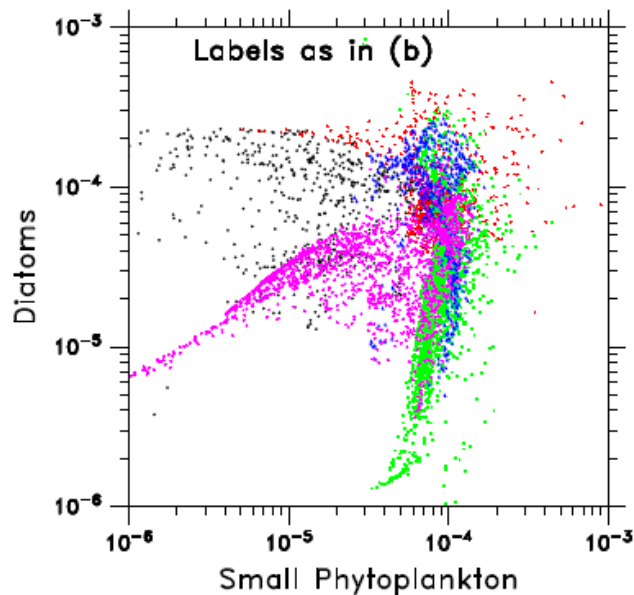
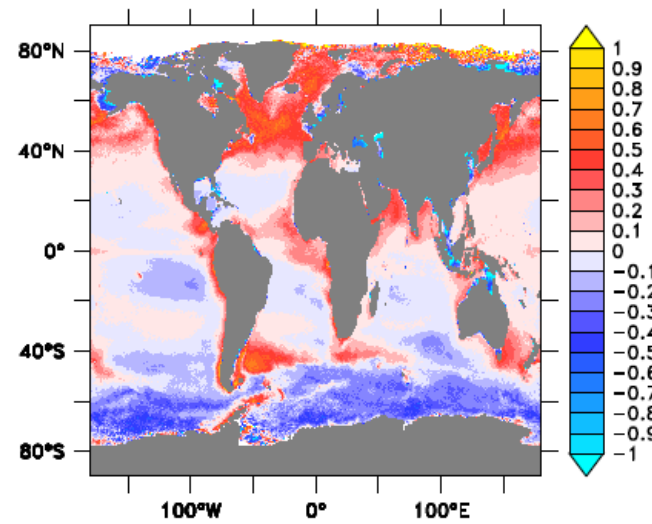
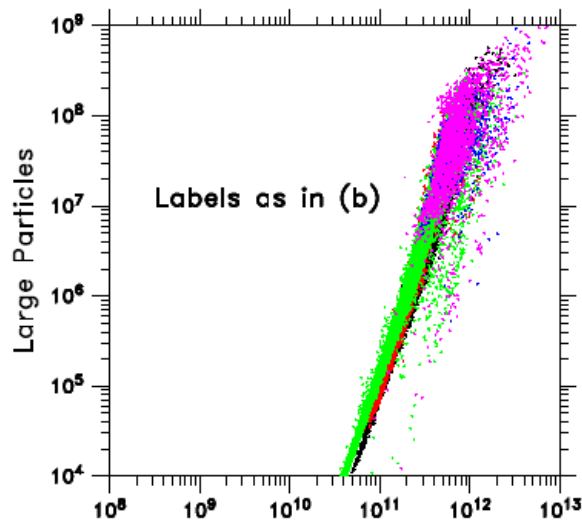
Siegel et al. 2005

Applications- Is there a spring bloom in the North Pacific?

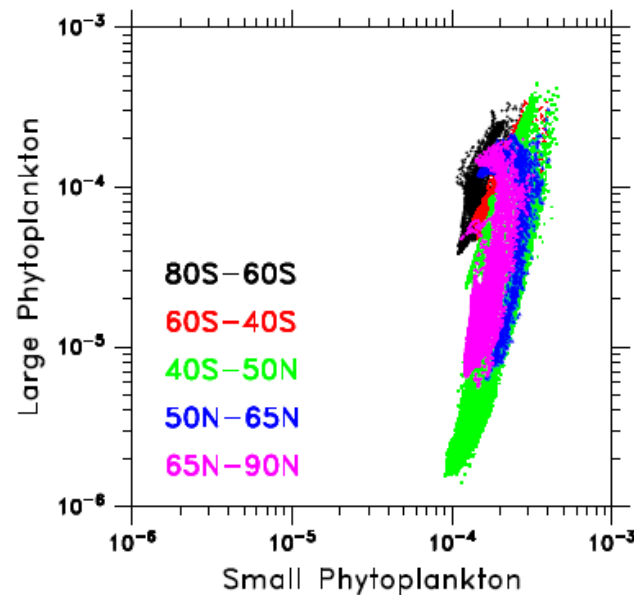


Schultz (2008) argued that iron was a potential explanation (linkage to ACE aerosols)

2. Backscatter spectrum and size structure



(a) Surface Biomass NCAR



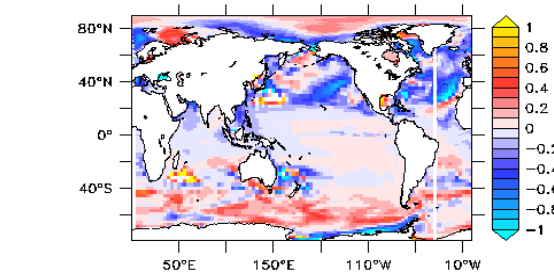
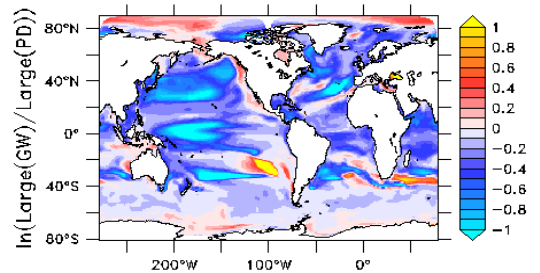
(b) Surface Biomass GFDL

Tiho Kostadinov
(UCSB)

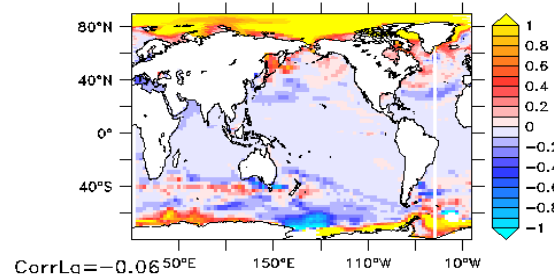
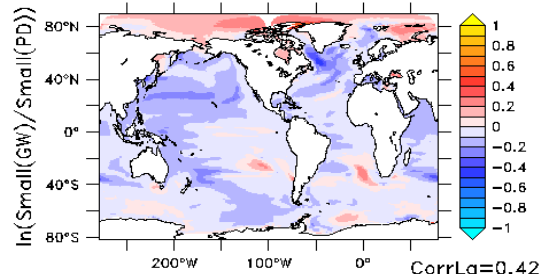
Both scaling
and deviations
from scaling
suggest things
about
underlying
dynamics-
again possibly
showing total
nutrient
limitation.

Applications: ecosystem change

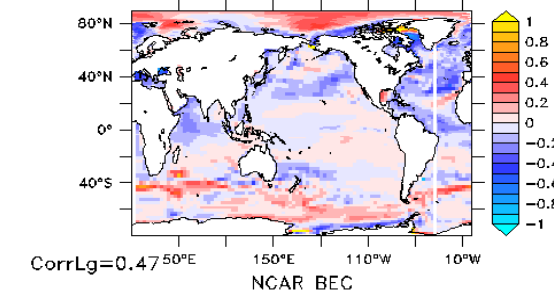
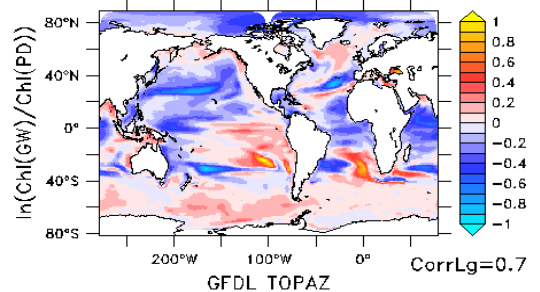
Large



Small



Chl



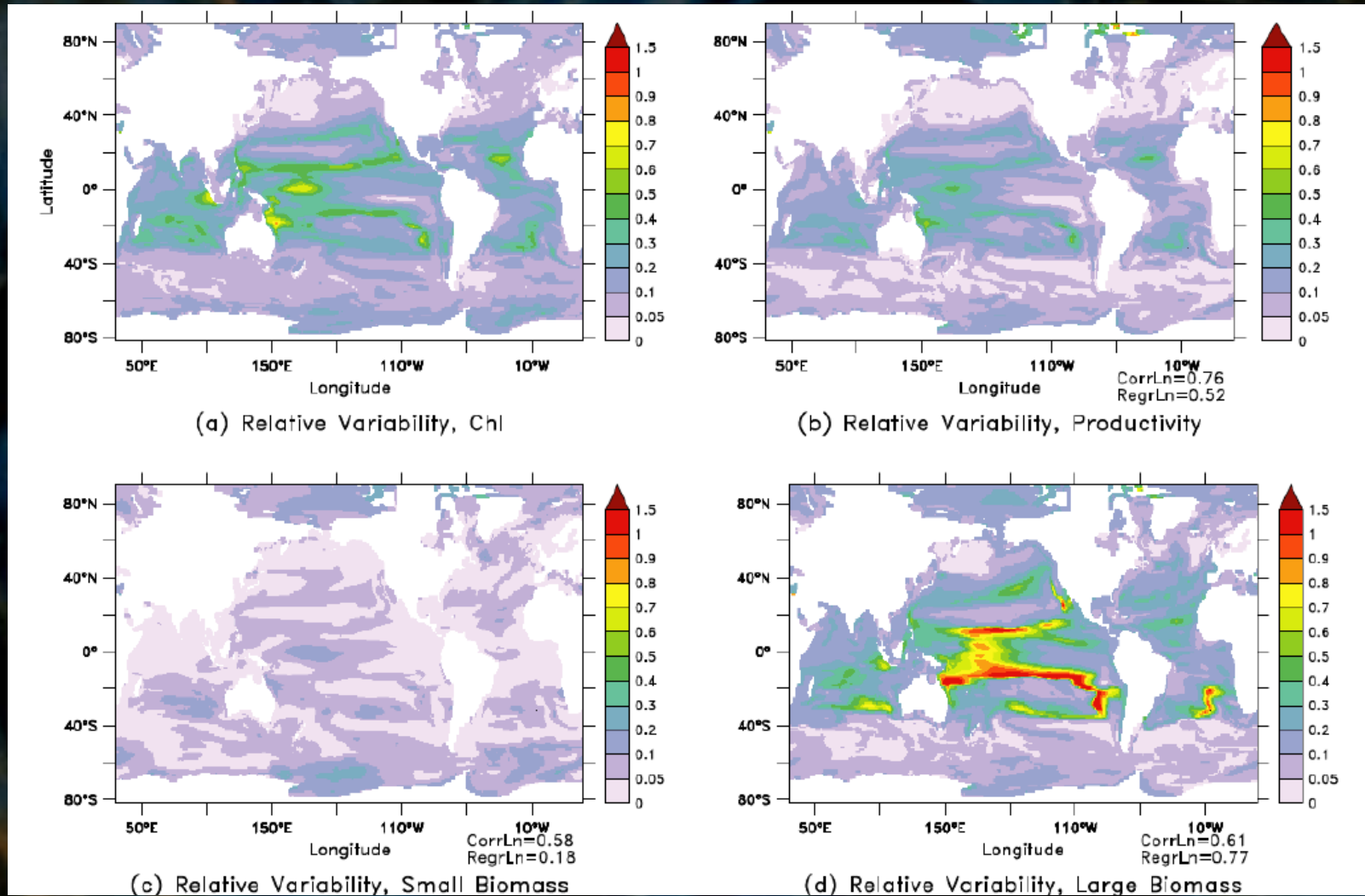
GFDL

NCAR

Big differences!

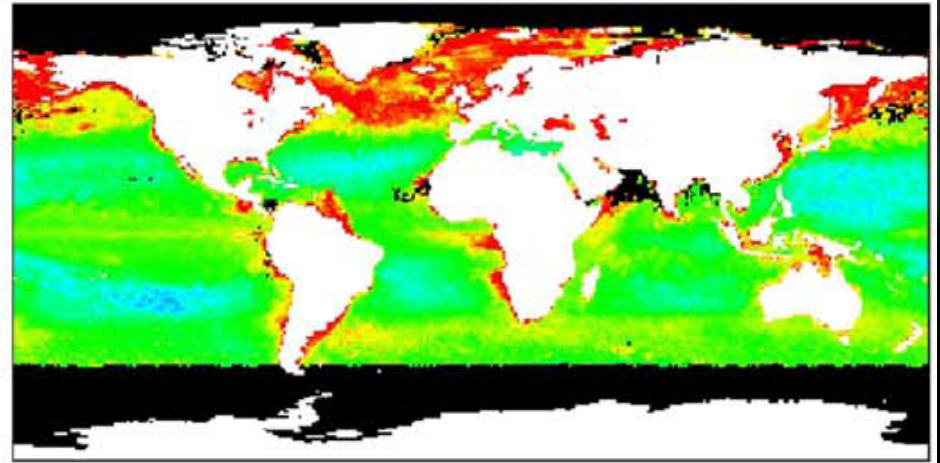
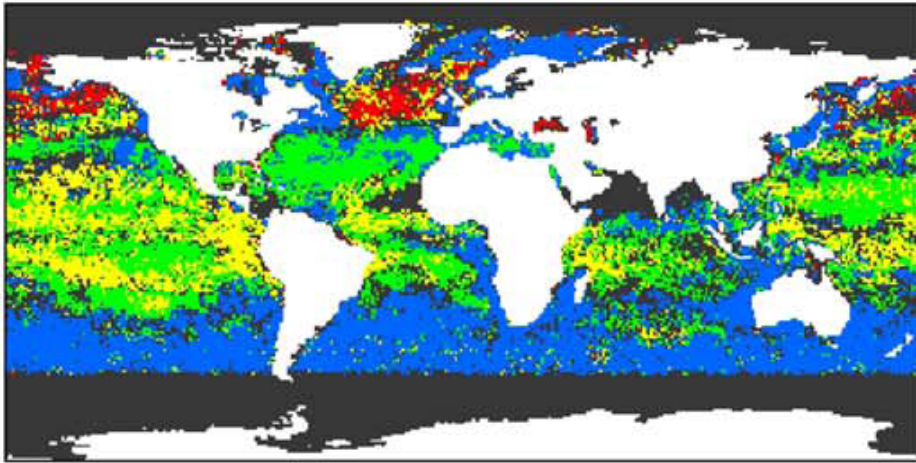
Can we use variability to tell who is correct?

Applications: Ecosystem variability



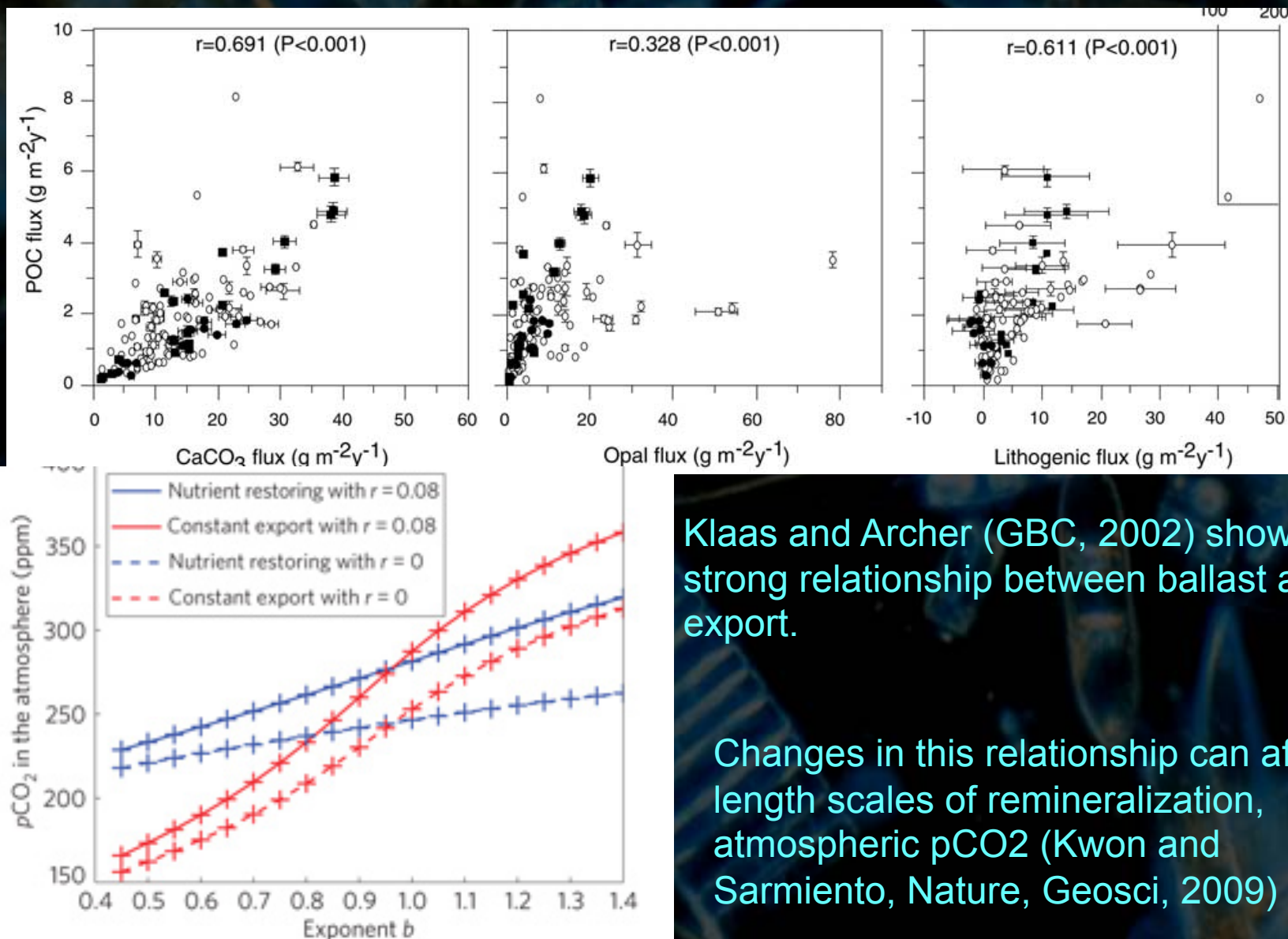
Gnanadesikan, Dunne and John, in rev. for ICES J. Mar. Sci.

3. Phytoplankton functional types



Alvain et al. (DSR,2005), distinguishes *Prochlorococcus*, *Synechococcus*-like cyanobacteria, diatoms and haptophytes (left). Chlorophyll (right) shows related patterns... but differing in key details.

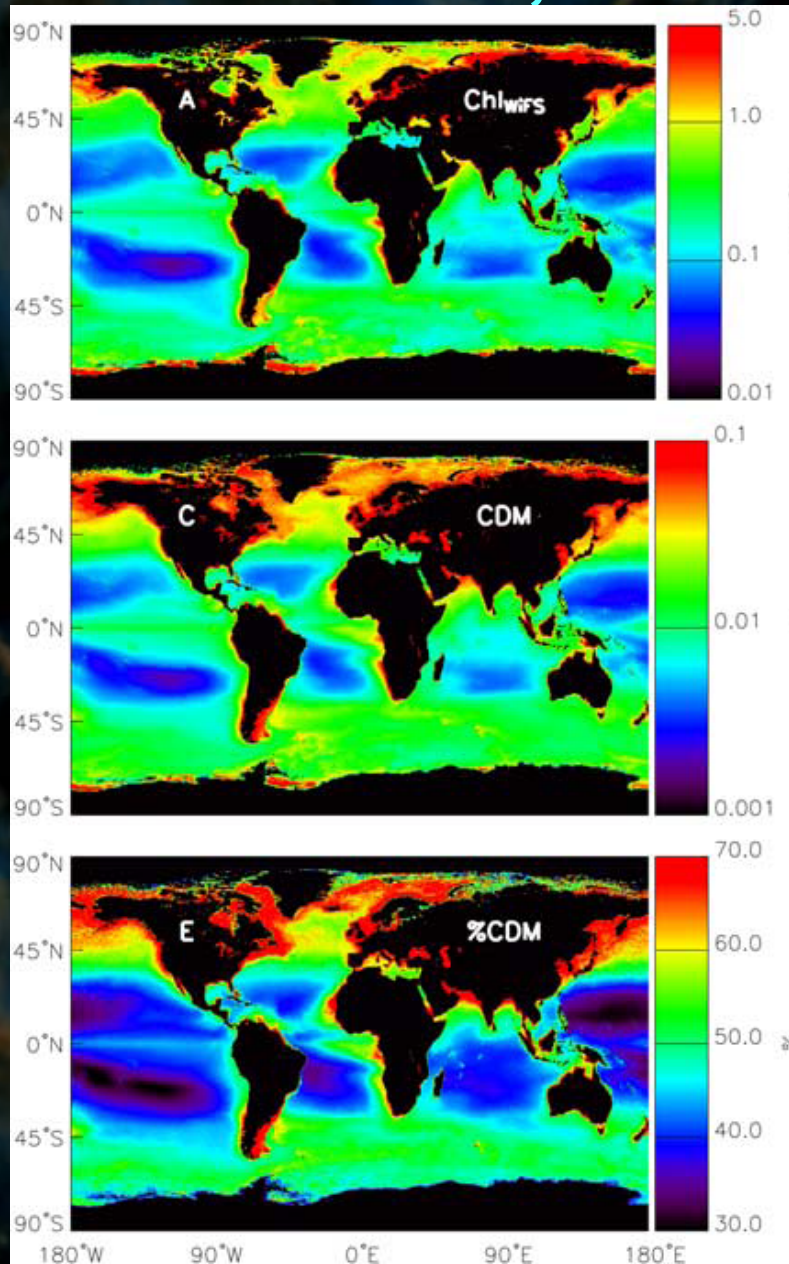
Applications: Carbon pumps



Klaas and Archer (GBC, 2002) show a strong relationship between ballast and export.

Changes in this relationship can affect length scales of remineralization, atmospheric pCO₂ (Kwon and Sarmiento, Nature, Geosci, 2009)

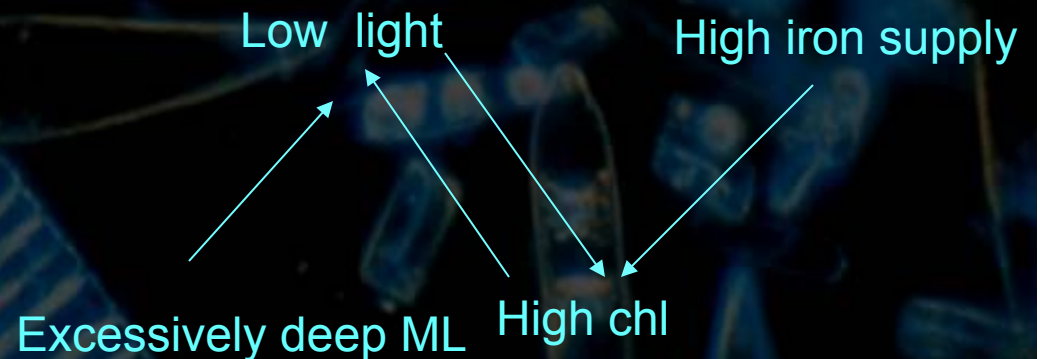
4. Chl, CDM and absorption



Siegel et al. 2005

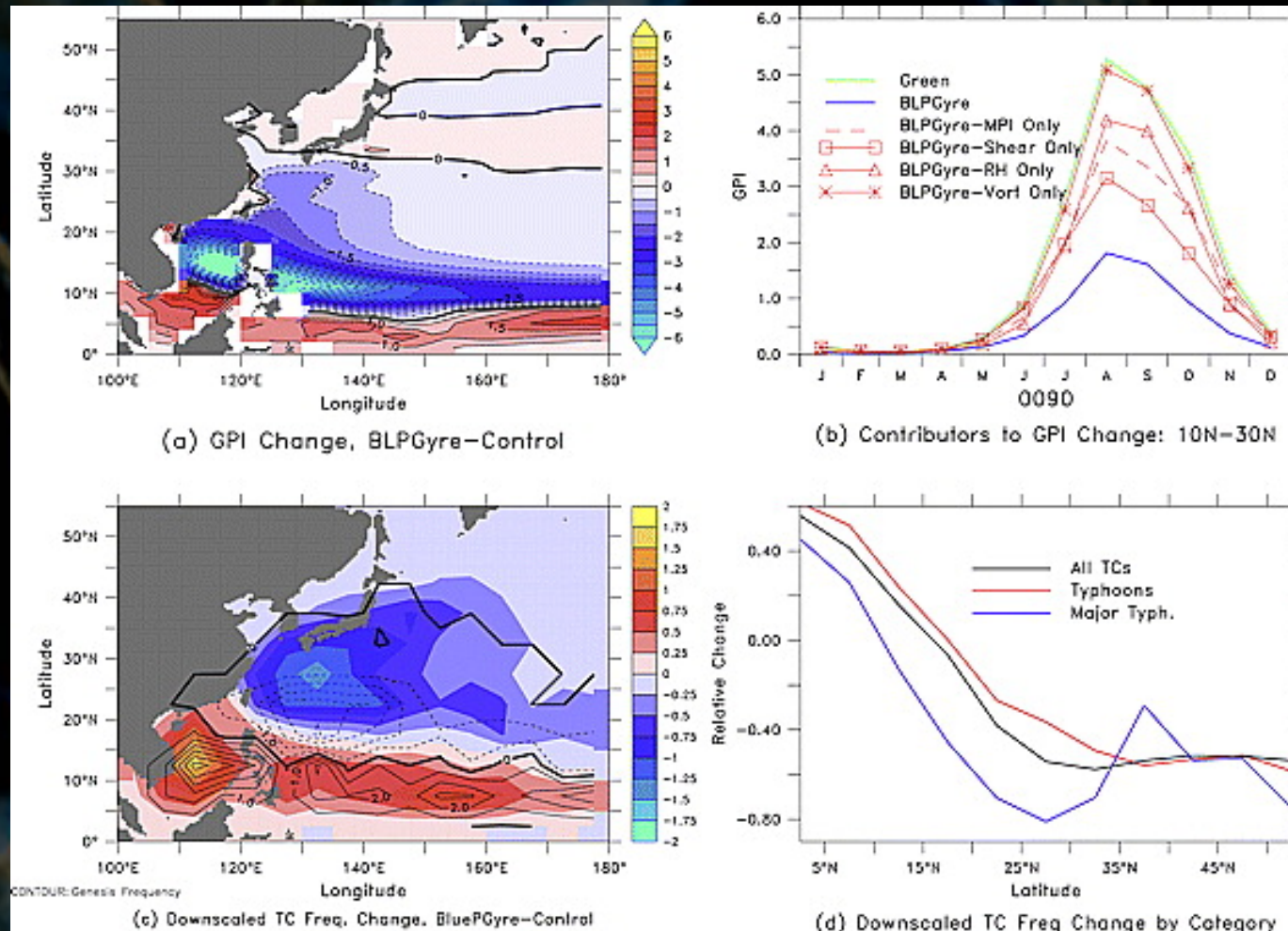
CDM has similar pattern to chl

...but time scales for evolution, feedbacks with physics are different.



CDM doesn't have these feedback

Application- Ocean color and hurricanes



Gnanadesikan, Emanuel, Vecchi, Anderson and Hallberg, GRL, 2010

Summary

- Characterizing the biosphere and its impact on carbon and climate requires more than chlorophyll.
- Exciting new products are in development, but many are not validated across range of ecosystems.
- Opportunity for ACE science program to advance our understanding of global ocean ecosystem function and its impacts.